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June 1965

THE ROLE OF IMAGERY EXPLOITATION IN FULFILLING THE INTELLIGENCE OBJECTIVES OF THE 1960's AND 1970's

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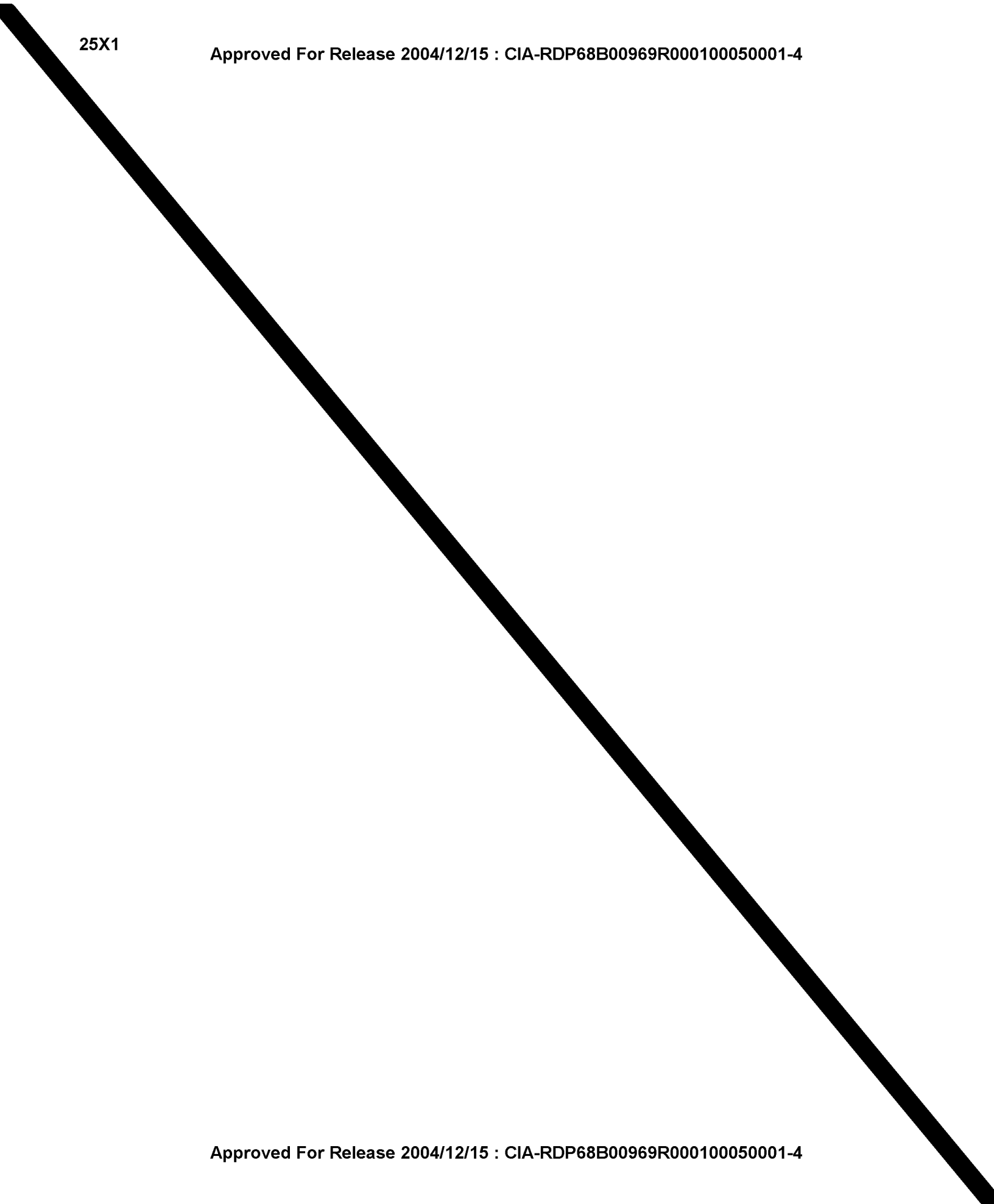

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16 June 1965

THE ROLE OF IMAGERY EXPLOITATION IN FULFILLING THE INTELLIGENCE OBJECTIVES OF THE 1960's and 1970's

(NPIC WHITE PAPER)

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I. INTRODUCTION

In the nine years since the introduction of the U-2 on the international scene, the growth of the role and importance of photography as a major contributor to both strategic and tactical intelligence has been dramatic. Photographic satellite systems have become operational to augment and supplant the high-level aircraft systems. New and remarkable photographic satellite systems are under development and these will be complemented by other image-forming, multiple-sensing systems. Improved manned aircraft developments are taking place and, at the same time, low and medium-level aircraft systems are in operation over many parts of the world. Rapid growth, both qualitatively and quantitively, has been the order of the day and the outlook for the future indicates even more impressive development at a quickening pace.

This paper presents the current status of the national photographic exploitation activity, framed against a background of its development over some 13 years, and sets forth its objectives to be achieved in the future, the assumptions on which these objectives are based, and the problems which should be dealt with if an adequate, national capability to exploit imagery in the on-coming years is to be achieved.

II. BACKGROUND

a. Development of a PI Capability in CIA (1952-1961)

Prior to 1952 there was no photo interpretation capability in CIA. In that year the DD/I, Mr. Robert Amory, Jr., recruited Mr. Arthur C. Lundahl from the Navy Photographic Interpretation

Center for the purpose of setting up a limited effort in this field. Mr. Lundahl grouped around him six people, most of whom were former associates, and the beginnings of a PI operation were underway. Even at that time the materials to be worked with were voluminous and the staff could only scratch the surface in a few isolated fields. The types of materials being exploited included clandestine hand held, captured German World War II, SENSINT Air Force peripheral, and Genetrix (balloon) photography.

The first development of real magnitude occurred in December of 1954 when Messrs. Dulles and Bissell brought Mr. Lundahl into the planning for the U-2 Program and instructed him to, among other things, prepare a plan for the exploitation of the expected U-2 photography which would begin arriving in 1956. Mr. Lundahl, with the help of others in the DD/I area, developed an exploitation program and presented his needs for a staffing complement to hopefully handle the proceeds of the U-2. Right from the beginning the concept of a team effort in the exploitation of photography was brought to bear. There were three prime goals in mind in the establishment of the PI operation of that day which remain even now as guideposts to the exploitation concept:

(1) Provide the photo interpreter with all-source collateral intelligence to assist him and make most meaningful his interpretation of objects imaged on the photography.

(2) Provide the photo interpreter with all forms of support necessary to the proper performance of his job including mensuration, editorial, graphical, photographic laboratory, etc. in order that his full attention may be devoted to the task of viewing and interpreting the photography.

(3) Produce timely, independent and unbiased photo interpretation reports which are uniformly disseminated to USIB member organizations as required.

To provide the capability and fulfill the goals established by Mr. Lundahl a new organization was formed in early 1956 under the codeword, HTAUTOMAT, which combined the small photo interpreter staff then working for Mr. Lundahl with a larger element of collateral, document, machine and other types of support specialists taken from OCR. The strength at that time totalled

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In July of 1956 the first U-2 mission was received and from that time forward NPIC and its predecessor organizations have been struggling to build and equip an organization capable of handling the continually increasing volumes of film which have been collected.

Throughout the period 1956-1961 the U-2 remained the principal collection vehicle and in its peak year, FY 1959, some 82 missions were flown producing over 450,000 linear feet of

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film. The U-2 shootdown in May 1960 over Sverdlovsk temporarily restricted the program but by August of 1960, only three months after the incident, the first KH-4 satellite mission was accomplished and the Center was thrown into a new era of exploitation.

Plans had been formulated by the Center and requests made for increased personnel resources and in December of 1960 a T/O

25X1 [redacted] The ceiling, however, was not increased until well into the year 1961, thus making the earlier T/O increase rather meaningless.

b. Establishment of NPIC (January 1961)

Planning was taking place on other fronts at the same time, however, and in December 1960 the Joint Study Group Report on Foreign Intelligence Activities (The Kirkpatrick Report) was issued. Among the various intelligence programs covered by this report was that of overhead reconnaissance. The following extracts from this report are pertinent:

> "A third major source of foreign intelligence is photographic and other visual-aerial observation. This is probably the most precise form of intelligence collection inasmuch as photography provides accurate information. The U-2 Program provided what was probably the greatest amount of valuable information obtainable from any single source, and the Study Group heard consistent requests that this program or something similar to it be resumed at the

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earliest possible date....The Study Group has spent many months discussing the problem of processing and interpreting aerial photography for intelligence purposes. The CIA, with the active participation of the Army and Navy, is administering an expanding operation which is now in effect a photographic intelligence center of common concern. However, this center is still operated today on a basis of informal arrangements....There is agreement within the Community that when the raw film is chemically processed, the photography should be distributed immediately to all parties of interest. There is also agreement in most of the Community that a central photographic intelligence center of common concern should be established."

The report concluded with the following recommendation, Number 16:

"The Secretary of Defense and the Director of Central Intelligence should consult preparatory to the early preparation of a new NSCID designed to provide authority and assign responsibility for the establishment of a National Photographic Intelligence Center (NPIC)."

In January 1961 President Eisenhower, in one of his last executive actions, approved NSCID 8 which formally charged the Director of Central Intelligence with providing a National Photographic Interpretation Center as a service of common concern.

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High among its principal responsibilities, were those of rapidly providing and distributing interpretation reports of photographic detail with supporting references to appropriate related collateral.

The concepts underlying the creation of a national exploitation organization were quite simple and were stated in the papers proposing and accompanying the NSCID as well as in the Directive itself. These included:

(1) "No complete separation of interest is possible or desirable in photographic intelligence activities."

(2) "To promote an integration of effort and to avoid unnecessary duplication and expense, a coordinated, interdepartmental approach to the exploitation of photographic intelligence shall be established."

(3) "Certain photographic intelligence functions can best be performed as a central service of common concern, for the maximum benefit of the entire Intelligence Community."

Overall then the basic concept or purpose in the creation of the national Center can be said to have been that of insuring the most effective, timely, and economic exploitation of photography for foreign intelligence relating to the national security.

c. Growth of NPIC (1961 to Date)

The establishment of NPIC as a formal, national organization brought new impetus to future planning for the Center and the Director of NPIC immediately convened a committee of representatives from the military services, State Department and CIA to

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consult on the methodology of operation, organization, and plans for this new Center. In late 1961 requests for increased personnel strength were approved and this time the ceiling authorization was granted as well. By then the resolution of the KH-4 system was improved from its initial resolution of approximately 50 feet and the periodicity of missions was already being planned for one per month. About this period, U-2's although no longer used over the Sov Bloc, were still in active use in other areas of the world including China, North Vietnam, Laos and Cuba. By the beginning of Fiscal Year 1963 planning was underway for a new satellite spotting system, ground coverage and resolution of the KH-4 system had been vastly improved, U-2 flights were still in use around the world and low-level military aircraft missions were being sent into the Center. The KH-4 had opened vast new horizons and demands placed upon the Center far exceeded its capabilities, particularly in the field of detailed analysis.

The Cuban Crisis came on in October 1962 and the Center was made the focal point of the readout of all Cuban overflight photography, a task which today has not completely subsided. The Center operated for weeks on end on a 24-hour-a-day basis and received the plaudits of the Intelligence Community for reading out all significant items of both the high-level and low-level collection efforts.

In the fall of 1962, and prior to the Cuban situation, the Center once again established the need for an increased staffing

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25X1 authorization and [redacted] positions were approved. Almost immediately, however, the ceiling was reduced [redacted] and shortly thereafter 25X1
25X1 increased [redacted]

The beginning of Fiscal Year 1964 brought with it another request from the NPIC for an increased T/O to cope with the then planned collection inputs, and an approval was given for [redacted] 25X1 positions. The personnel ceiling, however, was arbitrarily adjusted in February of 1964 [redacted] thereby bringing 25X1 almost to a halt a highly-productive recruitment effort which had been underway and which had enabled the Center to increase
25X1 its strength [redacted] in one year's time. The ceiling was
25X1 later increased [redacted] and the staffing authorization reduced
25X1 [redacted] to that level. The momentum of the large recruitment effort mounted in 1962 and carried on through 1963, however, is just now being regained after having been lost by the hold put on in February 1964.

In the interim, world crises have come and gone, the mix of collection systems inputting photography to the Center have steadily increased until today NPIC is handling some 18 low-level aircraft programs, 6 high-level aircraft programs and 2 satellite systems. Immediate readout of all systems is taking place in a timely fashion but second phase exploitation is often delayed and detailed reporting is falling far short of meeting the demands of the Community quantitatively and from a timeliness standpoint.

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Throughout this period all possible efforts were made to engage in the extensive development of new equipments and techniques and the improvement and automation of existing systems. Our R&D budget rose from insignificance in FY 1958 to a high of

by FY 1964. Excluding the costs of personnel, by FY 1964 some 60 percent of the manipulatable NPIC budget was being expended on research and development and more was asked for but could not be provided.

NPIC has pioneered in the use of automation to enhance the capability of its professional staff and the productivity of all of its functional activities. The first computer in CIA was the ALWAC 3E delivered to NPIC in 1957 to help in the solution of mensuration problems. Information storage in computers has been a standard practice in this Center for some years and since May, 1959, our first and second phase immediate reporting as well as a variety of other products have been computer-driven and printed. The Center's present building was wired for over 160 remote real time stations so that PI's might directly query the computer and installations are taking place continually in fulfillment of that program. Efforts in this regard have been greatly enhanced by continuous consultation with senior Lockheed personnel who are also under contract to NASA in the establishment of the Houston Space Center.

Throughout all aspects of the production operations of this Center the latest in equipment and techniques have been brought to bear. It has served and continues to serve as a model for other PI operations.

d. Current Situation

NPIC today lacks the staff and financial resources to adequately exploit the photography delivered from the collection systems in order to meet the demands of its many consumers. There is, however, no photography in-house which has not been scanned and at least a preliminary readout of it made. It is in the field of more detailed analysis required by production components that the Center is unable to keep pace. The Center operates today on a large scale much as the Integrated Operational Intelligence Center (IOIC) of the Navy does on a small scale. As pointed out above, NPIC has long made use of computers in the handling of its collateral data store, its mensuration work, and its production of reports. It has served as the instigator and champion of the use of all-source collateral intelligence in the exploitation of photography. It works as a cohesive, integrated, production element in turning out its many products. Unlike a relatively simple operation such as the Navy IOIC, however, which relys on only one basic input system, this operation must read out many different systems simultaneously. Furthermore, it has had no control over the collection resources so that they might

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be tailored to enhance and speed up the exploitation process. Conceptually, however, there is little difference between it and such an operation as the IOIC.

Remaining major problems of the Center at this time are coordination of collection and exploitation planning and firmer guidance from intelligence production elements which utilize photographic interpretation products and services.

III. ASSUMPTIONS FOR PLANNING

In planning for the future and in arriving at the increments of increase which have been specifically projected for the coming five years, many assumptions had to be developed. These deal not only with increasing volumes of current systems but the development of new photographic systems, technological advances in other sensor fields and assumptions concerning the role which NPIC will or should be called upon to play in the exploitation of such systems. The following then appear as the most important assumptions and must be validated before planning can take place:

a. Photography will remain and other forms of imagery will become key sources of "factual" intelligence.

There seems little question that photography is a unique source of factual intelligence. This was noted in the Kirkpatrick Report when it was stated that: "This (photography) is probably the most precise form of intelligence collection." The state of the art is rapidly advancing and systems are now being planned

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which will achieve resolutions [redacted] 25X1

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b. Satisfaction of intelligence objectives as being developed in the Fifteen Year Plan will require heavy inputs from photography and other image-forming systems.

With the U.S.S.R. remaining a principal threat to the U.S. for some years to come and with Communist China posing an increasingly powerful threat, continuing and enhanced multi-sensor coverage of these areas will be called for. Particularly as improvements in resolution and other technical advances take place, these systems will provide key ingredients to the solution of problems such as deployment of advanced weapons and weapons systems, strength of forces, deployment of forces, determination of military/economic capabilities, and eventually the early warning problem itself.

c. Technical advances in collection will enhance the intelligence value of imagery and broaden its use in the intelligence production process.

Improved scales and resolutions of photography coupled

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This quite obviously provides for a continuous surveillance potential of all enemies and trouble spots. In addition, it is forecasted that a remote, real-time collection system will come into being which will provide almost immediate readout of selected areas of the world. This can place the image exploitation operation right in the midst of the indications intelligence business. When coupled with the more standard but improved, returnable photographic packages, it will also place a monumental workload on exploitation resources. The image exploiter will be a major contributor to current intelligence products and, similarly, crisis management will rely heavily on such resources. Further, economic, industrial and agricultural research efforts of the Intelligence Community will be able to make significantly greater use of the detailed products, and in the scientific areas, each new level of detail opens new avenues of investigation and consequently increases the demand for image exploitation.

d. The concept underlying the establishment of NPIC will continue and become even more compelling in the ensuing decade.

The primary purpose in establishing a single, national exploitation effort was to insure the most effective, timely and economic exploitation of photography of national interest and significance. While there remain unto the individual departments

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and agencies exploitation responsibilities and tasks in connection with the fulfillment of their own missions, there is, nonetheless, a common interest on the part of all these establishments in seeing photographic products of true national significance turned out as rapidly, efficiently and economically as possible. A single group of interpreters and their colleagues in related supporting fields, responsive to a single management, develops a proficiency which, over a period of time, produces sound interpretive information acceptable to all consumers. A national operation, independent of analytical or evaluative groups or organizations, can produce unbiased, high quality intelligence. This, it is believed, is the reputation which NPIC has built and by performing the interpretation once, instead of having the identical readout proliferated among the many departmental components, the Center has unquestionably saved both manpower and funds for the government as a whole. There is every reason to assume that the efficiency and economy of operation and the proficiency and reputation for unbiased reporting which has been built by the Center will remain in demand and should be continued in the years to come. To allow the effort to fragment or to disintegrate after ten years of operation, almost five of which have been as a formal national organization, would be a great step backward.

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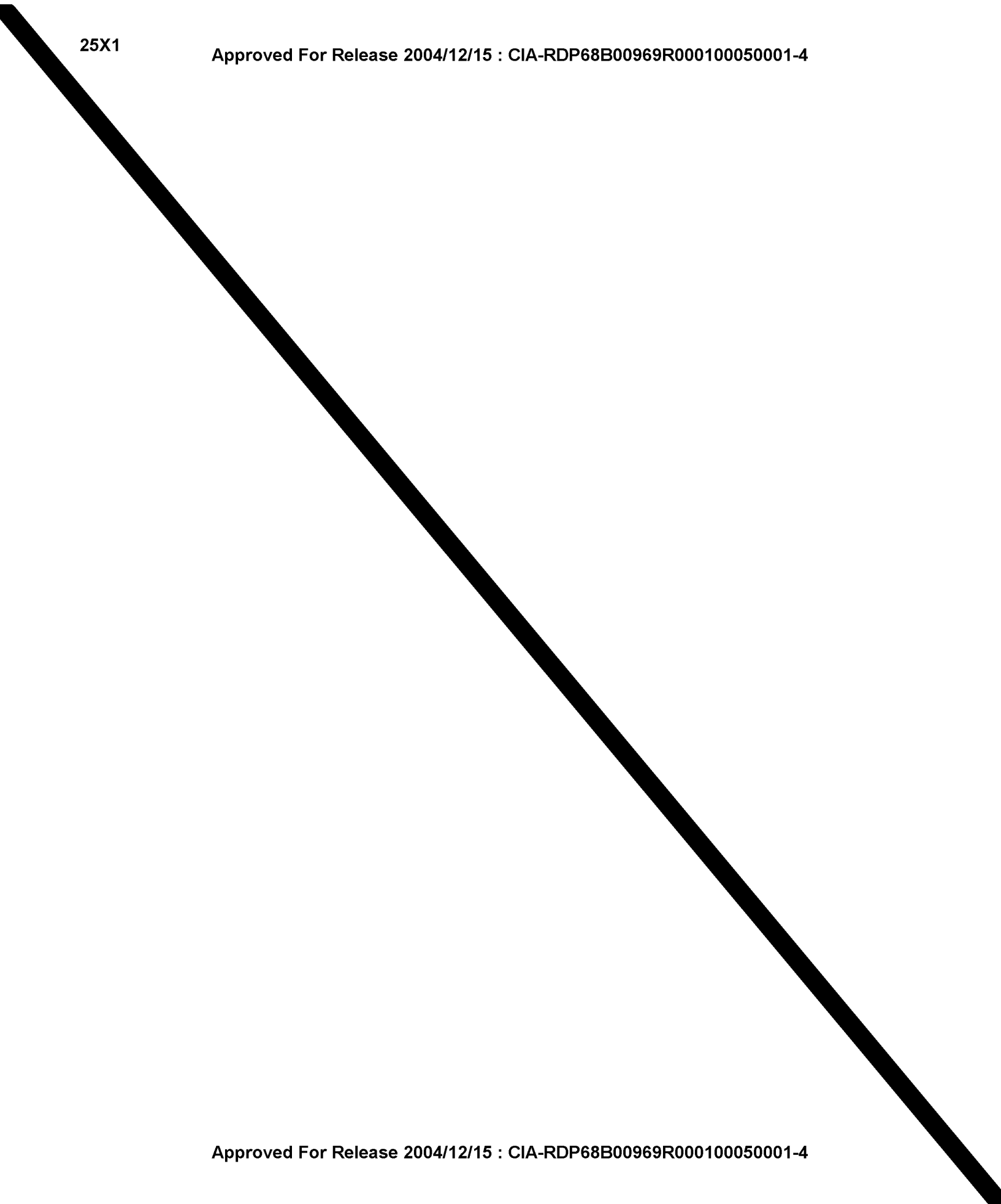

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IV. DISCUSSION

The assumptions set the stage for Center planning for the next five to fifteen years. It appears reasonably certain that enhanced photographic systems [redacted] 25X1

25X1 [redacted] will be major contributors to meeting many of the high priority Intelligence Community objectives of the ensuing decade. Further, it seems that the reasons underlying the initial creation of a single national organization to exploit photography remain and may well be more compelling in viewing the exploitation problems of the future. The complementary nature of the sensors, the similar disciplines needed in their readout and the capabilities of a single large organization to handle this mass of data on an effective and timely basis, all appear to dictate the wisdom of providing a capability for the singular exploitation of those targets and subjects of national significance and interest.

If this conclusion is valid, there are nonetheless many problems remaining and among them, one which looms large is the issue of coordination of collection and exploitation in both the planning and execution phases. Even a cursory review of the USIB minutes over the past months, and indeed years, will show that a very heavy percentage of that body's time was consumed in discussing, reviewing and deciding upon various aspects of the photographic collection program. Planning, even in great and minute detail, has been undertaken by USIB.

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By the same token, it is literally impossible to find even a mention of the ramifications of these collection programs on the existing exploitation facilities. Nowhere at the policy levels is there any real coordination or attempt to balance the programs of collection and exploitation. This has lead to imbalance in the past - it exists at the present - and if continued with the advent of systems now in planning, it will lead to chaotic conditions in the future.

The entire operations of NPIC for the FY 1965 cost less than one and a half KH-4 launches and even some of those NPIC funds were obtained by diverting them from other intelligence production programs within the Directorate of Intelligence. There seems little sense in, on the one hand, spending literally hundreds of millions of dollars for the collection of photography from both satellite and manned aircraft systems and at the same time giving relatively little attention to the exploitation facilities which must handle the inputs if they are to have meaning to the Intelligence Community. Proportionate attention must be given to the exploitation side of the reconnaissance picture. At the least, a much higher degree of coordination between both sides of the program must take place; at best, quite possibly a single authority over both national collection and exploitation should be established.

There may well be an analogy to be drawn between the evolution of the COMINT collection and readout programs and their final centralization

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in NSA and the current problems we are facing in the photographic field with multi-sensor imagery oncoming.

The outlook then is for more imagery of a variety of types, of higher quality and greater quantity, and an increasing demand on the part of the Intelligence Community for its rapid interpretation. A mechanism, the nucleus of an effort to adequately exploit it, is in existence. The capabilities of that exploitation effort must, however, be brought into balance with the capabilities of the collection effort to deliver raw materials. Better coordination including possibly central direction will have to be achieved.

V. OBJECTIVES

The basic objective of the reconnaissance program overall should be to provide maximum contribution to the satisfaction of intelligence objectives in the timeliest fashion at minimum cost. This should be the basic aim of both the collectors and the exploiters. There is no other purpose in their existence. In order to achieve this there must be, among other things, an overall balanced program, so that the exploiter is capable of satisfactorily handling the inputs of collection systems and, conversly, that he does not have an over abundance of resources in comparison with the collection effort. Therefore, it would seem desirable to establish as the next objective a program designed to work toward integrated direction of collection and exploitation of imagery to insure a balanced program of maximum benefit to the Intelligence Community.

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The photographic reconnaissance program of the government is one of, if not the, most expensive intelligence collection and exploitation efforts. The DCI and the USIB set the requirements which in turn determine the collection programs. This is a national effort. From the exploitation standpoint, the DCI is charged with providing a national photographic interpretation center as a service of common concern. The center is in existence, functioning satisfactorily and capable of being expanded to handle on-coming photographic inputs and other [redacted] Another objective should be, therefore, to promote and enhance the status of this national organization so that, in one spot, the factual information to be derived from the read-out can be extracted for use by the entire Intelligence Community.

The objectives, simply stated, are:

a. Render maximum contribution to the satisfaction of intelligence objectives in the timeliest fashion at minimum cost;

b. Work toward integrated direction of collection and exploitation of imagery to insure a balanced program;

c. Promote and enhance the status of a national organization capable of interpreting the imagery collected and producing, in a single spot, factual information for the use of the entire Community.

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VI. CONCLUSIONS

25X1 a. Photographic [redacted] sensors produce information much too valuable to remain unexploited.

25X1 Photography [redacted] will be one of the prime sources of information to satisfy many priority intelligence objectives of the next fifteen years. As quality increases and the level of details exposed to analysis grows, the answers to many more unsolved questions will become available. A capability to exploit these sources must be made available.

b. Technological advances in collection will increase the quality and quantity of information available.

25X1 New systems, [redacted] photographic

25X1 satellites [redacted] all point the way to greatly increased quality with resolutions [redacted] 25X1

25X1 [redacted] In addition, as the size of U.S. boosters is increased, the pay loads to be carried may be enlarged and the film loads expanded accordingly. Greater detail, and much more of it, will require a significantly expanded exploitation capability, notably in terms of people and funds, particularly for continued research and development.

c. If leadership in exploitation is not maintained by the DCI, it may by default pass from his control or be fragmented.

Adequate and rapid exploitation of imagery is a necessity in the Intelligence Community today. If the resources to support

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this exploitation are not provided by the DCI, it must be assumed that the rest of the Intelligence Community will not be willing to sit by and see the imagery remain unexploited. One of two alternatives will possibly obtain:

(1) another department, probably Defense, would most logically request that the control of the exploitation activity be transferred to it or;

(2) each department and agency would attempt to form its own exploitation organization capable of handling mass volumes of the imagery.

d. A fragmented exploitation program will cost the U.S. far more than the national program now possible of achievement.

This would appear to be obvious and need little elaboration. One of the basic purposes of establishing NPIC was to effect economy of exploitation. Although it can not be conclusively proved, it would certainly appear that economy and proficiency have been achieved. To splinter the program at this point among duplicative exploitation efforts could only result in cumulative higher costs.

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AUTOMATION IN NPIC
1955-1970

1. Introduction

Automation has been a basic ingredient in the planning process of NPIC from its inception. During the early stages of the U-2 program in 1955, it was obvious to the planners that the problem of rapidly handling large inputs of photography with limited available staff could be handled only through the application of equipment and techniques to speed up the production process at every phase possible and get the job done with minimum numbers of personnel. The name chosen for the exploitation phase of the Program, Project HTAUTOMAT, was symbolic of this concept which has carried through to the present day and is an essential part of the planning for future development. Within the photographic intelligence community, NPIC has become highly regarded for its accomplishments in automating the PI process and is looked to for leadership in this field.

2. Automatic Data Processing NPIC

a. Present ADP Philosophy and Structure

Of primary importance in automating the PI production process has been the application of automatic data processing equipment and techniques to those phases of the work susceptible to automation. The original concept of Project HTAUTOMAT envisaged using the Minicard System as a mechanism for storage and dissemination of imagery collected by the U-2 system. With the Minicard equipment on hand, it was natural that it should also be

applied to the storage and retrieval of document images to provide collateral support to the photo analyst. To supply additional summary target-oriented background information, a system was evolved wherein an "encyclopedia" was maintained in punched-card form and reproduced prior to the start of first-phase exploitation for any mission. From this came the present procedures of supplying "Target Briefs" to the PIs for each mission, and the partial mechanization of first and second phase report production with automatic incorporation of the substance of these reports back into the Target Brief File. Begun on conventional tabulating equipment, this system was eventually transferred to an IBM 1401. This, together with the Minicard establishment, constituted the automatic data processing operation of the Data Management Division and later the Collateral Support Division

Concurrently, management determined that electronic computers would be used to facilitate the various computational procedures of analytic photogrammetry necessary to meet analyst requirements for derivation of metrical information from photography. In 1957 the Agency's first computer (ALWAC III E) was requisitioned. To improve the response time of the system to the requirements, the concept of dispersed photomeasurement equipment on-line with a common computer was developed. The actual implementation of this system has proceeded with the acquisition of the UNIVAC 490 as the computational element for the system. The criteria on which this selection was based were derived from postulated peak loading requirements, as are the criteria used in design of any "real-time" system. One consequence of designing for peak loading is that total central processor

normally required for the so-called "real-time" application is only a small percentage of the total available. In this particular instance a substantial amount of time is required for executing batch programs that support the "real-time" system, but well over 50 percent of total main frame time is still available for other purposes. As the Photo Measurement System moved toward realization it became more and more deeply involved in problems arising in the creation and manipulation of large data files.

The UNIVAC 490's file manipulation capability (coupled with a central processor with time available for multiple processing) and the lightly loaded printer offered an obvious solution to the overload on the IBM 1401 that resulted from the increasing size of the Target Brief File and higher frequency of success in collection efforts. Looking further ahead, the existence of an extensive system for intra-Center communication with the U-490 central processor offered an interesting vehicle for experimentation with various approaches to"on-line" information retrieval that might greatly reduce the amount of Target Brief printing associated with each collection effort. These considerations dictated a centralized approach to the use of such equipments in support of NPIC's photo-exploitation activities.

On 4 May 1964 an Information Processing Division was established in NPIC by merger of the personnel and equipment of the two groups previously mentioned. IPD is responsible directly to the Executive Director, NPIC for providing on-line, real time and batched scientific computation, and information processing and data retrieval computer services in support of NPIC, and the departmental activities of the

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Service/Agency Detachments and select components of the Intelligence Community. The consolidation of NPIC's human and physical ADP resources into a single management entity is proving to be a significant contribution to NPIC's ability to maintain its leadership in the development and implementation of the most effective and efficient data processing techniques used in the photo intelligence community.

b. ADP Programs

Ongoing ADP programs in NPIC may be divided into four major categories: the Photo Measurement System, the Data Handling System, Document Storage and Retrieval, and the Management Information System.

(1) Photo Measurement System -- The Photo Measurement System involves reduction of time, attitude, and position information to obtain parameters for each frame of photography necessary for distance, direction, and position computation. The pre-processing programs are completed and operational for reducing attitude and position information from various current collection systems. Similarly, programs are available for obtaining these data from inertial navigation systems. Programs are being developed to handle other current systems and systems now under development.

Having determined frame parameters, measurement computations can be made for each camera system and for each measuring instrument. The necessary programs exist for batch processing of data from comparators and for on-line real-time processing of data from the [redacted] dual screen 25X1

25X1 comparator, the [redacted] film reader and the [redacted] chip comparators. 25X1

The on-line system may be used to determine distances, azimuths, geo- 25X1

coordinates, and area measurements. Programs to permit plotting of imaged points are being completed.

(2) Data Handling System -- This system centers around the Target Brief File. It currently has approximately 19,000 targets under machine control. These targets may be retrieved by identification numbers, geo-coordinates, and by security classification. Programs are being checked out to permit retrieval of targets in sequence of coverage.

Target Briefs generated for use by the PIs include a work sheet page on which the photo interpreter drafts his report. This draft is converted to machine language by an editorial assistant operating an 826 document-producing typewriter, permitting machine formatting and generation of the report at the completion of the reporting cycle, the preparation of paper tape for communications use, and the updating of the Target Brief file with the latest available information.

(3) Document Storage and Retrieval -- This system involves the All Source Index and Minicard System. The All Source Index lists all PI reports which are received or produced by NPIC and is published in quarterly editions in both Secret and codeword versions with a circulation of about 300 and 100 copies respectively. The Minicard System contains 16-millimeter chips of all formal PI reports received or produced by the Center, of informal reports produced by CIA/PID, and of mosaics overlaid on WAC charts (used for determining coverage of specific areas).

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(4) Management Information System -- This system accounts for the progress of projects through NPIC and for the allocation of resources within NPIC. The flexibility of this system allows not only a continuing analysis and review of the allocation of the Center's resources in relation to current operations but also permits statistically valid projections of long-term Center requirements as a direct function of input parameters programmed by the collecting organizations.

c. Projection of Requirements (FY 1966-1970)

During the next five years, electronic data processing services will be extended to all NPIC activities where the computer can be efficiently used to improve productivity, both quantitatively and qualitatively. The extension of on-line remote terminals, tailored to the needs of individual customers being served, will receive primary emphasis, but the development of new (and the refinement of existing) batch processing programs to meet the evolving needs of the Center will continue to require substantial effort.

Computer support to the photo interpreter and photogrammetrist will receive primary emphasis. The on-line real-time mensuration capability which now exists at three stations will be extended to additional stations as equipment becomes available, and will be expanded to handle camera systems now under development. Additional routines will be programmed to permit plotting of measurements made, either at the precision coordinatograph located in the computer area or on remote Calcomp plotters located in the PI areas. Most important will be the development of height measurement capability from stereo photography.

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The most significant advance in assistance to the total PI production process will likely come from the addition of on-line cathode ray display tubes. Initially these will be used in drafting reports, replacing the present IBM 826 card punching operation. Later as an extension of work already underway, a query capability will be added, permitting call-up of desired information from the Target Brief File, the All-Source Index, and similar data base files. If it is desired to retain the data a hard copy printout can be obtained. Finally, the feasibility of utilizing a graphic display and manipulation capability (cf. DAC-1) will be studied. This capability would permit the operator to create and annotate rectified line drawings on the CRT, using a light pen to trace desired forms roughly and then using dimension, direction, area, and coordinate information derived from precision measurements made on optical equipment to automatically rectify, dimension and label the CRT drawing. Since the information displayed on the CRT will be digitized, it can be drawn to desired scale on a precision plotter. Once the shape of an object has been determined, the computer can create any desired plan, section or perspective drawings either fordisplay on the CRT or for plotting. "Snapshot" techniques, probably in conjunction with the Photo Chip System, can also be developed to document measurements for recall and reference when the target is again measured. For efficiency, the Photo Measurement System should automatically flag those targets being measured repetitively and for which measurements are on file.

An initial CRT will be introduced during FY 1966 to determine PI acceptance, develop programming experience, and experiment with the

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man-machine interface. If successful, the objectives outlined above will be completed within the five-year period.

Programs will be completed during FY 66 for automatic plotting of mission coverage based on data received over the 1004 data link. These will provide graphic and tabular portrayal of both the area and the targets covered in forms suitable for either publication or display. Attitude reduction programs will be completed for reduction of stellar, horizon, and inertial navigation data for all systems of concern. Similarly, programs for reduction and portrayal of information contained in data block will be written.

Several innovations will be made in present methods used for report generation. Use of CRT's for data input has already been mentioned. In this connection, we plan to explore the feasibility of developing syntax and editing routines to assist the PI in drafting his reports, to standardize formats, to verify place name spelling, provide coordinate information, etc. We expect to convert to upper and lower case computer type for immediate reports. For detailed reports we will examine the feasibility of computer driven typesetting. Most significant, however, will be the development of the Basic Information Reporting System (BIRS). This system will extract information from immediate, "special" detailed (e.g., MILOB) and other reports and compile summaries in accordance with customer's requests.

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It now appears that several components of the Center have valid requirements for remote access to the central processor for immediate input of data, very rapid calling of relatively short (i.e., less than 10 minutes) batch programs to process that data, and immediate return of end results. We propose to evaluate the cost-effectiveness of such a remote-access system and, if appropriate, proceed with the development of appropriate extensions to our executive routines and procurement of suitable remote station equipment.

During FY 66, the Management Information System will receive a complete overhaul designed to simplify processing, improve response time, and provide accuracy checks for all steps of the System. The possibility of using remote stations (where they exist for other purposes) for input of certain MIS data while continuing batch input of other data will be explored. We will develop graphical presentation of management data, projection techniques, and exception reporting.

A generalized circulation control system will be developed using teletypes strategically placed throughout the building to request film, documents, books, maps, or photo-chips. If the desired item is on-the-shelf, delivery instructions and charge-out records will be typed out at the appropriate repository; if it is charged-out the requestor will be informed of its whereabouts. By-products of the system will include overdue lists, inventory control, catalog cards, accession lists, document receipts, etc., as well as the information needed by the transport system proposed for development by P&DS. The system will also support the Photo Chip System under

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development by P&DS, batching requests and supplying manufacturing and dissemination instructions. The initial system will assume the requester has identified the item he wants; later a query capability will be added.

The Minicard System will receive a thorough overhaul. Work is already underway to develop computer search techniques to identify the Minicard wanted. If the techniques prove more economical than the present electromechanical search, we anticipate the evolution of the system into a microfilm/microfiche system. New materials and techniques of reproduction will be examined for potential savings without sacrificing quality.

The above objectives will require considerable modification and extension of our computer hardware. Our objective is to acquire sufficient general-purpose computing capability to handle all normal requirements and anticipated peak loads on a three-shift basis within acceptable limits of queing and delay. Further, we will obtain at least two central processing units, each of sufficient capacity to handle the Center's time-critical production requirements and thus provide back-up for essential work. The Minicard System will be operated on a two-shift basis for the foreseeable future; it may be necessary to go to three shifts in FY 68.

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3. Automating Other Phases of the Production Cycle

Although application of ADP provides the core to automation in NPIC, extensive efforts have been carried on in automating other functional aspects of the NPIC production process. Whole families of equipment and techniques have been developed, modified and planned to handle the ongoing problems in the photographic interpretation, mensuration, collateral support, publications, photographic laboratory, file and distribution, and reproduction functions of the Center. (See Tabs 4 and 5 on Research and Development Programs.) The automating of these functions will not be dealt with in this study, but can be developed in the same detail as presented for the ADP operations of the Center. However, the historical development of the equipment and techniques used in the production process only serves to illustrate a basic management concept of the Center to never be satisfied with the status quo and to continually seek new and better methods of accomplishing our basic responsibilities.

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REVIEW OF THE RESEARCH & DEVELOPMENT EFFORT - NPIC

Since the establishment of an independently managed and budgeted R&D program for the Center, emphasis has been placed upon improving the total photographic analysis process in order to keep abreast of the increasing quality and quantity of photo and other imagery inputs.

To accomplish this, effort has been directed toward a number of separate but related areas with the expectation that advances in technology would allow automation of those functions susceptible to it in order to match the pace of improved and augmented human-oriented operations.

Fundamentally, the photo-interpretation operation is one of human judgment. Since this is so, every conceivable method to enhance the interpreter's performance and efficiency has been applied to his task. Extensive instrumentation in the form of high-powered stereo-microscopes, rear-projection viewers, and sophisticated viewing tables have been constantly provided and up-dated. Even his working environment has received the most careful attention from a human-factors point of view. In addition, considerable work has been done to try to understand more completely the human motivation-stimulus-response habits which make for efficient and accurate

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interpretation judgments. Promising research in this area has been accomplished and increased attention is planned for the future in view of even higher quality photo materials and the more exotic sensor images expected by the Center.

By far the largest consumers of manpower in the Center are the supporting operations. These are areas in which the functions performed lend themselves to extensive automation and machine assistance. These functions include provision to the interpretation operation of multitudinous collateral data, photogrammetric back-up, detailed graphics, photo laboratory image manipulations, and finally editorial and publishing functions. Technology is being advanced by the R&D staff of the Center in most of these areas with guidance from among the country's leading specialists in the appropriate disciplines.

The net result of the Center's R&D program to date can be summed up to show: (1) A substantial fund of knowledge of the photo-interpretation process, which is certainly the foundation for continued work in this area to allow the human portions of the operation to be maximized as a function of the volume and variety of materials expected for analysis. (2) The application of machine techniques to all Center operations of the type which indicate that improvements in efficiency can be gained by automation.

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In the period of initial formation of a photo interpretation capability in the CIA, which evolved into the present NPIC, instrumentation was at almost a primitive level, primarily consisting of the residue from the P.I. efforts of the military in World War II. Of course, the quality and quantity of materials available for interpretation were significantly lower than planned for as products of the U-2 and its greatly advanced capability. Spurred by the U-2 and its camera developments, extremely rapid strides were made to match the level of exploitation with the new high photographic quality.

The photo interpretation industry was pressed into entirely new concepts. From pocket folding stereoscopes, technology, primarily directed and sponsored by NPIC, was advanced until stereo-microscopes became the workaday tool. A successive progression of improvements through at least a dozen models has been the result of this one item alone, and through this effort new standards of optical performance have been established for the entire photographic intelligence community.

Like progress resulted in other areas. Specifications established by the NPIC, with design concepts proposed by Center technical personnel, have led to development and multiple production of the highest quality photographic enlarger ever built. These are now standard items for use with material of

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the variety regularly received by the Center.

The whole concept and implementation of the on-line precision mensuration system was a result of NPIC initiative and direction. Where slide-rules and desk calculators were adequate in pre-U-2 days, these were successively replaced by precision measuring engines with shaft rotation encoders, then automatic paper tape punching and hard-copy printout, and now binocular and stereoscopic measuring machines with teletype access to the presently operating UNIVAC 490 computer. There is no finer photo mensuration equipment available than that currently in use at the Center. Initially, stereo-comparators, designed for cartographic purposes, were imported and adapted to meet our peculiar requirements for accuracy, for they were the very best available. Today, second generations of this equipment are being replaced by NPIC designed items. Some are equipped with granite slabs as the measuring base, using interferometric techniques, as our accuracy requirements continue to climb. Feasibility studies in the use of lasers as a more precise measuring tool are currently under contract. Already NPIC has the only prototype laser light-source enlarger in existence, and it is being subjected to rigorous evaluation to determine if this is the way of the future for equipment with extremely high transfer function capabilities.

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In the collateral data handling operations, progress has been made from the early use of file cards in cabinets to sophisticated equipment such as the Eastman Kodak Minicard System and the use of IBM 1401 computers.

The Center R&D activities in the period up to the present have proven to be extremely productive, especially considering the limited funds available. Good program management practices and close direction of all R&D sponsored by the Center have insured the unusually high rate of developmental success. The R&D projects and their results have been fully shared with the other members of the photo intelligence community, and these have set the pace and example for practically all quality-oriented photo interpretation operations in the free world.

With the minimal and often frugal R&D effort sponsored and directed by the Center up to this point in time, photo interpretation and analysis has managed to just keep up with the materials received to date. There is every indication that the magnitude of the Center's exploitation operation will have to make a quantum jump forward. The budget level devoted to R&D in the past will certainly not allow the Center to perform in such a fashion as heretofore in view of the complexities and sophistication of materials to be received in the very near future.

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PROPOSED FIVE YEAR RESEARCH AND DEVELOPMENT PROGRAM

Planned for extending the Center's R&D activity into the years ahead is a 15-point program designed to bring to bear the best minds and most advanced technology in the country directly on the critical development problem areas of the Center.

An examination of the key functions of the interpretation and reporting process has highlighted the areas which have resisted more complete machine manipulation and automation. A coupling of this with an extension of work underway on the human aspects of the P.I. process provides the basis for the 15-point program. It is intended that these critical operations receive intensive development support in an all-out attempt to achieve significant break-throughs in the technology.

It should be noted that the currently allocated R&D budget for the Center will do no more than pay lip-service to many of the points in the proposed development program. Over a year ago an annual R&D budget was proposed which called for reasonable expenditures in excess [redacted] 25X1 dollars. As only about one-half of this amount was forthcoming, the planned program was pared back proportionately with the obvious sacrifice of lead-time resulting. The projected R&D funding requirements for the coming five-year period reflect the level of expenditure calculated to exploit the current state of technology which can be brought to bear on the Center's problem areas.

Following is a brief description of each of the fifteen major development areas selected for intensive investigation during the coming five-year period. [redacted] 25X1

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Explanation of Major Development Programs

1. Automatic Target Recognition

Automatic target recognition has received significant attention since 1960. At least 20 major corporations are now actively involved in the development of automatic target recognition systems. The predicted increase in acquisition materials indicates a corresponding increase in imagery information to be interpreted. 25X1 [redacted] machine analysis. The combination of the anticipated increases in information to be processed and the increased proportion of images in electronic signal form, indicates the critical need for automation. In spite of the effort already directed toward the development of these systems, the science is still in its infancy.

The primary development thresholds to be crossed are those of bandwidth, signal-to-noise-ratio, prenormalization, generalization, and discontinuities. The NPIC program includes provision for extensive theoretical and feasibility studies in the early stages, which are directed toward achievement of relatively primitive automatic pre-screening systems by FY-68 and the development of comprehensive automatic imagery classification systems by FY-70.

2. Automatic Stereo Scanning

In spite of the fact that present and future collection systems achieve stereoscopic acquisition, the stereoscopic coverage is often only utilized for detailed examination. No exploitation system exists whereby it is operationally feasible to scan in a stereoscopic mode. It is the opinion of many that important intelligence, sometimes imperceptible in the monoscopic scanning process, would be evident in a stereoscopic presentation.

The preliminary problems in the implementation of an automated stereo scanning system have been identified to be automatic stereo correlation, automatic distortion compensation, and a method of stereo-presentation not requiring viewing aids.

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The NPIC development program is designed to attack these problem areas through intensive theoretical analysis, feasibility studies, and equipment breadboarding. Both direct and rear projection stereo-scanning systems will be investigated and developed. The first fully automated direct viewing prototype is planned for delivery in FY-69 and the first fully operational rear-projection system in FY-70.

3. Photo Interpretation Module

Past development programs, designed to support efficient exploitation of reconnaissance imagery, have been so burdened with the obvious basic requirements for viewing and mensuration systems, that little time could be given to less obvious but equally important details. We now find that there is very limited knowledge concerning the best characteristics for the illumination of image interpretation systems or the surrounding environment; the benefits and limitations of the team concept; the optimum basic equipment, considering the effects of its size, proportions, and placement; and the most efficient means for supporting the interpreter through automatic information and materials handling. It is apparent that judicious implementation of such knowledge would significantly improve the efficiency of the image interpretation process.

In order to achieve this improved efficiency, there must be a comprehensive study program to define: pertinent characteristics of the sensory, mental, and physical processes involved in image interpretation; the proper characteristics of light in all types of viewing equipment and their environment; and appropriate levels of automation in the handling of collateral information and operational acquisition materials. These studies will be closely followed by the implementation of new and improved exploitation techniques and the design and fabrication of optimized image interpretation work spaces which are properly finished, equipped, serviced and organized for highly efficient image exploitation operations.

4. Data Link

This development program is keyed to the anticipated advent of real-time, image-transmitting systems for reconnaissance acquisition. Systems of this type will require completely new exploitation techniques and equipment, differing in basic principles from those currently in use. Studies will be needed to define this type of exploitation. Reproduction, storage and retrieval, viewers, and mensuration equipment must be developed in consonance with the needs of the exploitation components. In short, an entire exploitation system for in-house use must be defined and developed.

The NPIC Data Link Development Program is planned as an advance response to the advent of this type of acquisition system. Allowances are made for the increased complexities imposed by security requirements, the possible inclusion of color, and the transmission of infrared and radar imagery on a real-time, around-the-clock, all-weather basis. The likelihood of fundamental advances in image transmission technology is also anticipated.

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5. Image Analysis Program

In recent times, there has been a mounting conviction that lack of knowledge concerning the basic nature of images is handicapping the exploitation effort. There are a number of unanswered questions about images which appear to hold important keys to their ultimate usefulness as a means of communicating intelligence. Representative examples of these unknowns are:

(1) Comprehensive, rigorous descriptions of image formation, recording and transmitting processes.

(2) Comprehensive evaluations of imaging systems as a means of remote sensing of the real world.

(3) Means of compensating for image degradation caused by acquisition, reproduction, transmitting and viewing processes.

The Kinzell Committee has confirmed the limitations of knowledge in these areas and recommended their investigation. The NPIC development program has been, and is responsive to these recommendations. The image analysis program will achieve the most advanced level of knowledge possible concerning images as a means of communicating intelligence about the real world. This knowledge will be used to achieve ultimate levels of image exploitation.

6. Human Factors

Advanced knowledge of all the human aspects of the image interpretation process is required for intelligent pursuit of all the other categories of the development program. Definitions of the process are critically needed to determine optimum ground-resolution/intelligence-yield relationships criteria for intelligent selection and utilization of personnel and well-designed training programs.

This program contributes to the Photo Interpretation Module, but is distinct from it. The human factors program is more generic and will cover all aspects of human performance in the image interpretation process for an indefinite period. Knowledge from the human factors program will be used to initiate or contribute to equipment development programs. It is anticipated that knowledge gained from this program will be highly-relevent to the problem of devising conceptual logic for automatic image recognition systems and defining optimum man-machine relationships.

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8. Direct Viewing Systems.

Direct optical viewers continue to be the highest performance means for presenting perceptible images to the interpreter. Due to the rapid advances in acquisition resolution and the anticipated variations in film widths, the present standard direct-viewing equipment, the [redacted] Zoom 70 microstereoscope, is rapidly becoming obsolete. Whereas steps have been taken to delay this obsolesence, total replacement of some 300 of these instruments should be accomplished by the end of fiscal year 1968. In addition, further automation and improvements in illumination must be developed to keep these systems serviceable in exploiting the acquisition materials of the future.

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The NPIC direct-viewer development program provides for the replacement of the Zoom 70 by higher performance instrumentation as well as the development of highly automated direct-viewing systems. There are also special developments such as the defraction grating virtual image viewer, which promises to provide the image quality of the direct-viewer with viewing ease approaching that of projection viewing. The development of an automatic stereo-scanning direct viewer justifies a separate major program which has been previously described.

9. Rear-Projection Viewing Systems.

Rear-projection viewing is still preferred for the scanning process and offers the only means for simultaneous group analysis. The rear-projection image has always been inferior to the direct-optical image (such as that seen through microscopes) due to the washed-out, granular appearance caused by the screen. In previous years the image quality of acquisition materials was not sensitive to this difference; however, the present quality levels have exceeded the display performance of our current standard equipment. In addition there are significant problems with the illumination, the film transport, and the lens systems.

This NPIC development program includes component development intended to solve limitations of the present rear-projection viewers. Improvements in lenses, film transports and stages, illumination, and screens are being pursued. Allowances are made for the integration of these components in the design and fabrication of advanced rear-projection viewers. This program supports, but does not duplicate, the separate stereo-scanning, rear-projection viewer development program.

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10. Modulated Light Imaging Systems.

Images recorded by reconnaissance systems are generally extremely small scale replicas of real-world scenes. The range of tones captured on the photograph often exceeds the accommodation range of the human eye. Sometimes the acquisition system introduces spurious tone effects such as hot spots, flare and halos. All of these characteristics tend to cause difficulty in the image perception process. Attempts have been made to eliminate these effects by converting the image to an electronic signal in order that the unwanted information (noise) may be identified and compensated -- thus "enhancing" the signal and the TV image by which it is displayed. The limited quality of the TV process has more than offset any image "enhancement" that might have been achieved by this technique. However, the fact that important near-subliminal, intelligence-bearing images are sometimes missed gives testimony to the need for such enhancement.

The modulated light imaging systems in the NPIC development program are in response to this important requirement. It is believed that full development of these systems, which will automatically control viewing and reproduction illumination as a function of local characteristics of the image, will eventually achieve a significant improvement in the perceptibility of near-subliminal imagery. Appropriate developments in the direct and rear projection viewing programs will also be utilized.

11. Materials Handling

The increased work loads predicted indicate that significant advances in the automation of materials handling must be accomplished. Problems exist in the areas of both collateral and operational acquisition materials. Systems are needed for reduction in storage requirements and for automation of the storage, retrieval, accountability, transport, and loading processes. One of the most significant problems is that of roll-film handling. Presently the film is stored on spools in cans. It is, for the most part, stored, retrieved, accounted for, transported to, loaded on, and threaded into the viewing equipment by manual processes. Collateral materials such as maps, charts, reports, and previous photography are handled in much the same fashion. Whereas the present handling processes are well-organized and economical, the increased requirements for materials handling caused by increases in acquisition materials may necessitate substantial automation.

The NPIC development program must comprehend this problem area. Studies are planned for analysis of current procedures, predicting workloads, establishing practical levels of automation, and recommending detailed alternative solutions. As a result of these studies appropriate hardware will be developed. It is anticipated that control will be handled by a central computer in keeping with the present procedures. One anticipated development is an automated, roll-film, handling system

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which will employ roll-film magazines, having machine-readable identification. These magazines will be automatically stored, retrieved and accounted for and transported between the storage vault and specific operational zones. The magazines will require a simple manual insertion into the viewing equipment, after which the film will be automatically threaded for subsequent viewing.

12. Information Handling Systems

The increased exploitation requirements resulting from increased and improved acquisition materials will magnify the amount of substantive and mensural data which must be handled. Significant strides have already been made in this area. It is now possible for the interpreter to inform the central computer of a mission and exposure number through a teletype keyboard, and receive on the same teletype, hard copy describing the location, time, and attitude of his photograph. He can, in a similar fashion, receive accurate ground dimensions by inputting corresponding image points through a highly-automated film reader. This program is in the first stages of implementation, and there is still much to be done. For instance, new acquisition systems will provide a data block on the exposure or on associated magnetic tape. Automatic coordinated reading of this information will acheive greater operational simplicity, speed and accuracy than the previous manual input system. Collateral graphic and substantive information is generally handled as hard copy often requiring considerable research and manipulation on the part of the interpreter. The interpreter, in turn, records his substantive comments and mensural data in hand-written form. This data is typewritten, key-punched and entered in the computer. Most of the collateral information and the interpreter's report could be handled through direct communication links between the analyst and the computer.

Consequently, this program is designed to study and develop systems whereby the operational photo interpreter may communicate directly with a large-capacity, computerized, information storage system in order to determine collateral information and to up-date intelligence. This program includes the development of highly versatile data block and time-pip readers which are keyed to the automation of both the substantive reporting and the mensuration processes. Information will be displayed through a high-speed electronic system which is capable of handling images as well as printed information.

13. Reproduction Techniques and Materials

In the past, acquisition systems advanced more rapidly than the corresponding reproduction technology. As a result, instances occurred in which it was not possible to make work copies of a quality commensurate with that of the original material. In addition, the distortion characteristics changed to forms which could not be removed by conventional optical

rectifiers; consequently correctly proportioned plan views of significant installations had to be achieved through tedious and time-consuming analytical techniques.

The purpose of this program is to develop reproduction techniques and materials which will anticipate and accommodate changes in acquisition materials, so that high-quality working copies may be rapidly reproduced in response to specific exploitation requirements. Typical examples of the past requirements are: automatically-dodged copies, specific density cuts, and photographic enlargements. Future requirements will involve all of these plus the additional complexity of color duplication, image restoration, line-scan compensation (Radar images), image integration and manipulation, and photographic rectification. In addition to the development of systems for satisfying these requirements, this program also includes the development of unconventional reproduction materials, which may become competitive in performance and be much simpler to process than those currently in use. This will facilitate quick response by the lab and possibly lead to some immediate-access reproduction capability for the interpreter. 25X1

14. Mensuration Systems

Mensuration development needs have centered around two basic requirements, speed and accuracy. The advent of new acquisition systems having improved resolution, new distortion characteristics, and new SI packages cause very severe problems in the mensuration process. These invariably require up-dated or new equipment, new computer programs, and new techniques. Another fundamental problem in the mensuration process is the determination of the object edge from the image edge. At this point microdensitometric techniques are far too slow to provide significant assistance except in isolated cases.

This portion of the program provides for the development of a new highly-automated, high-performance, high-speed stereocomparator which is keyed to the anticipated characteristics of new acquisition systems. Funds are also provided for up-dating stellar comparators and the development of new high-speed, high-performance, rear-projection roll film readers. Most of this equipment will be designed for either IBM card input-output or on-line, real-time operation and analysis. In some cases the feasibility of including small special-purpose computers will be investigated. Electronic-scanning microdensitometry will be investigated. Electronic-scanning microdensitometry will be investigated as a possible solution to real-time edge definition. Allowances are also made for the development of advanced, highly-automated, versatile, analytical stereo-plotters and high-precision, high-speed, on-line, electronic plotters each of which will be used to provide the interpreter with precision line-drawings, directly extracted from imagery.

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15. Miscellaneous

There are numerous problems in the exploitation process which require individual development effort. A major group of such problems are related to special-pupose viewers. Because of their unique characteristics these viewers are not included in either of the specific viewer categories. Examples of these special requirements are: image-rectifying viewers (this is a real-time display requirement not to be confused with the rectifying printer); change-detection viewers; image-integration viewers which will utilize the capacity for integration and accommodation by the human visual system to integrate successive images of the same object; image-manipulation viewers, which will provide real-time capability for altering tonal range and tone-frequency relationships for investigatory purposes;

and color-enhancement viewers for converting the grey-scale to a color-scale to evaluate the effect on image interpretability. In addition to these, short range direct development services for all the NPIC operational divisions are included in this category.

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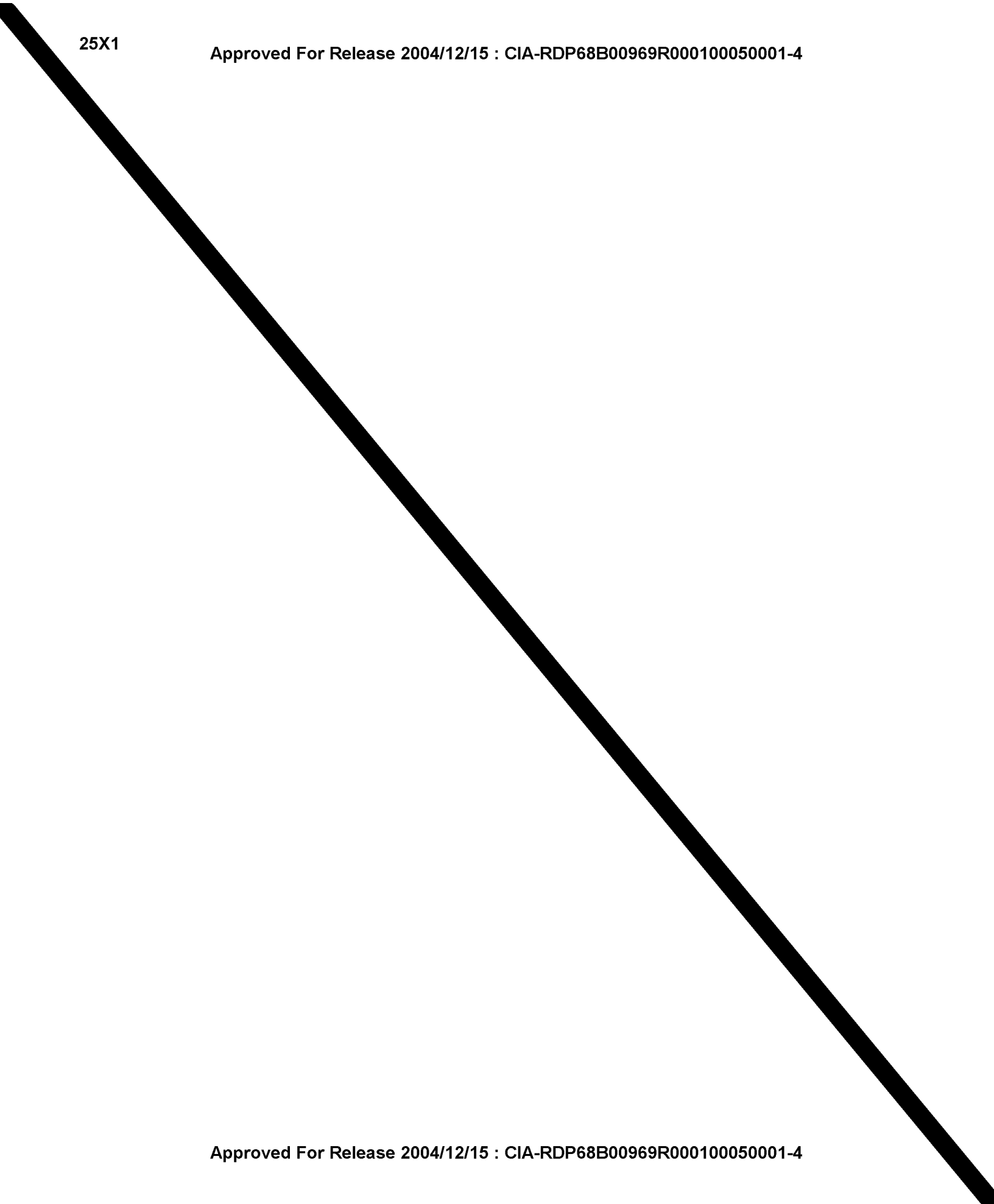

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